CANADIAN HYDROGRAPHIC SERVICE

the canadian hydrographic service

Canadian Hydrographic Service,
Marine Sciences Branch,
Department of Energy, Mines and Resources,
Ottawa, Canada.

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Hydrography is the charting of navigable waters, a craft that is as old as map-making itself. In fact, it would be no exaggeration to say that historically it is the most important branch of map-making. Travellers proceeding over land could usually ask their way from town to town, country to country. If there were no roads to follow there were at least river valleys and other natural landmarks. And, unless they chose to travel through a moonless night, the ancient wayfarers could at least see natural dangers and obstacles ahead of them.

But the mariner, then as now, is alone with the monotonous sea and the heavens as soon as he loses sight of land. It is true that to the experienced eye the appearance of the water may indicate the presence of dangerous shoals or currents, but this is a very uncertain guide, and of no use at night. It is therefore extremely important for the sea-farer to have instruments which, so to speak, would make dangers to navigation "visible". This was achieved by the production of charts and books of sailing directions. When used together with such navigational aids as the compass, the sextant and, in modern times, electronic positioning equipment, these charts and books not only tell the mariner where the dangers to navigation are, but also what course to steer to avoid them in the most effective manner, taking account of prevailing winds, currents, sea ice, etc.

At first, such charts and sailing directions were compiled simply from information collected from sea captains who had "been there", and who kept a record of what they had found. Late in the 18th century, however, the British Admiralty set up a service of ships and chart-makers whose sole business was to survey the seas and to produce charts and sailing directions for the Royal Navy and, later, for merchant shipping as well.

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Until late in the last century the Royal Navy did all hydrographic surveying in Canadian waters. Captain James Cook, the famous 18th-century explorer, learned the craft of hydrographic surveying in the Atlantic waters off Newfoundland. Many of the original surveys in the Great Lakes and the River and Gulf of St. Lawrence were carried out by Henry Wolsey Bayfield, an officer of the Royal Navy. His Canadian career spanned more than half a century and his charts were the foundation on which most subsequent Canadian hydrographic surveys were based.

The Canadian government began to carry out its own hydrographic surveys in 1883 and in 1911 its Hydrographic Service had completely taken over from Britain.

Today the Canadian Hydrographic Service is a division of the Marine Sciences Branch, Department of Energy, Mines and Resources. It uses a fleet of about eight ships and about one hundred surveying launches (the number changes from year to year, as new vessels are commissioned or withdrawn from service). Its operations range from the northern tip of the Canadian Arctic to the Caribbean, and, in addition to saltwater, cover navigable inland lakes and rivers. It has a large technical establishment at its Ottawa headquarters, where field data are processed and published in the form of charts and books.

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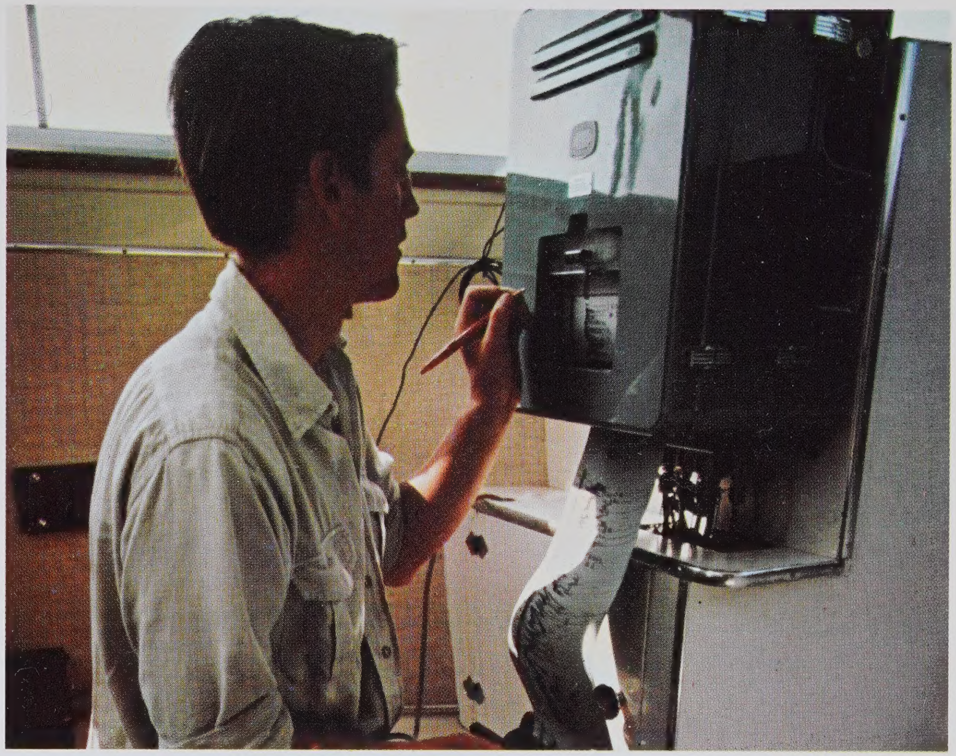
Canadian Survey Ship *Baffin*, one of the world's most modern hydrographic ships.

The most common and fundamental operation in hydrographic surveying is sounding, i.e., measuring water depths. No other assurance is so important to the ship's captain as the knowledge that he has enough water under his ship's keel. So effective has hydrographic surveying become that, whereas grounding was once by far the most common cause of shipwrecks, it now ranks well down the list of hazards. The first feature that a layman will notice when looking at a hydrographic chart is a veritable "soup" of tiny figures scattered about the water, each giving the water depth in either fathoms or feet. (A fathom equals six feet or 1.83 meters. Many nations give soundings in meters, and Canada has also begun to produce some charts in meters.) For centuries, and still within the memory of older Canadian hydrographers, soundings were obtained simply by lowering a lead weight on a wire. This method, while accurate, is extremely time-consuming and does not give a continuous "profile" of the bottom. However, for detailed wharf surveys in harbours where closely spaced soundings are required, and for shoal examination, the leadline is still used today.

The modern method, now in general use, is the echo sounder, which sends a series of sound signals to the bottom whence they return an echo to a receiver in the vessel. The deeper the water, the longer it takes for the echo to reach the ship. The elapsed time is recorded automatically on a moving graph, thus yielding a continuous record of the bottom profile. Furthermore, it can penetrate to great depths, beyond the reach of the conventional lead-line.

soundings and positions

Seaman marking a fix on an echosounder graph.



Taking fix by sextant on survey launch.

Hydrographers observing position of survey mark on rock in Georgian Bay. These marks are used for fixing positions of survey launches.

Hydrographers and seamen erect a Hi-Fix mast on mossy island off Newfoundland's east coast. Mast sends out electronic signals used in position-finding.

Soundings, of course, would be of little value if they could not be located precisely on a chart. For this reason, the hydrographer must always keep track of his own position. In former days, when surveys were usually conducted within sight of shore, this was done exclusively with the aid of the sextant. A sextant is an instrument for measuring angles, and may be used while the ship or launch is in motion. A typical sextant "fix" consists of simultaneously measuring two angles between three clearly marked "stations" on shore, the positions of which are known from previous measurements. From this, it is possible to plot the exact position of the vessel at the time the angles were measured.

Although the sextant is still standard equipment on inshore surveys, it is gradually being replaced by electronic positioning systems that allow the hydrographer to work out of sight of land or in poor visibility. These, like most such systems employed in navigation, depend for their distance-measurements on phase differences between radio signals emitted by two or more shore stations. An explanation of these systems would be fairly complicated and could be fully understood only by someone familiar with electronics. In practice, the system is fairly simple to operate. Its main feature is transmitters and receivers equipped with counters, much like the odometer in a car, from which the position of the ship can be read off at a glance. However, being delicate and complicated pieces of equipment, these units are apt to fail occasion-

soundings and positions

ally, causing unwelcome delays in survey operations. Whereas the hydrographer of older days had to be a rugged seaman and a good mathematician, his modern successor has to be something of an electronics expert as well, the more so as his instruments are undergoing constant development and improvement, a process in which he is encouraged to participate.

Since both visual and electronic position-finding require shore stations, the first task of a hydrographic survey team is to set up such stations by a combination of triangulation and traverse — time-tested survey methods — and to tie them to existing geodetic control points. Today the task of traversing has been made easier by the use of the tellurometer, an electronic system that accurately measures distances between stations. The second task of the hydrographer is to install a temporary tide gauge at the site of the survey. By carefully monitoring the times and heights of the tide's movements, he is able to reduce all his soundings to the lowest normal state of the tide, thus providing the mariner with a safety factor built into the chart.

soundings and positions

Hydrographer under a survey beacon operating tellurometer, an electronic device for measuring distances, on barren Arctic coast.

Survey launch is being lowered from hydrographic ship.

All the ships and launches used by the Canadian Hydrographic Service have been designed especially for surveying. Although a few older vessels still survive, most ships are of postwar vintage and were built expressly for the C.H.S. They possess special facilities for handling survey launches, current meters, bottom-sampling equipment, geophysical instruments, and the like. The largest hydrographic ship, the 3,700-ton *Baffin*, has landing and hangar facilities for two helicopters. She is equipped with three echo sounders, one of which is capable of penetrating to 6,000 fathoms ; Decca and Loran position-finding sets ; a satellite navigation system ; several types of radio transmitters and receivers ; and other aids to navigation and communication. She can carry a complement of 21 hydrographic and scientific staff and 81 officers and crew. The *Baffin* is capable of uninterrupted cruises up to 14,000 miles and has modern, comfortable quarters for all personnel.

A number of smaller ships have also been put into service recently, each carefully designed for greatest possible efficiency, ease of operation, and comfort. One of these is the *Parizeau*, a multi-purpose ship capable of tidal and current surveys and hydrographic and oceanographic activities in northern Pacific and western Arctic waters. The *Parizeau* was commissioned in 1967 and is based at the C.H.S.'s regional office in Victoria, B.C.

The *Richardson*, a rugged little sixty-foot ship has made two adventurous cruises through Bering Strait to Tuktoyaktuk at the mouth of the Mackenzie River from her home base, a round trip of over 7,000 miles. Because of the ship's size, the chief hydrographer has to double as captain, a most challenging task. The *Richardson* spends the winters frozen solidly into the ice and, in June, is reactivated for a short, hectic season surveying the western Arctic waters.

ships and men

It is possible to carry out hydrographic surveys in North Atlantic and North Pacific waters only during summer, since ice and bad winter weather make soundings impractical. However, hydrographers may be assigned to oceanographic and other ships that range far across the ocean even in winter. In former days, sea captains had little interest in water depths beyond the reach of their anchor chains. Fishermen, however, have long been aware that concentrations of fish are related to the existence of "banks" or plateaus of relatively shallow waters, such as the famous Grand Banks of Newfoundland. Depths on the Grand Banks average 35 fathoms, and they extend off Newfoundland for 350 miles. Anti-submarine warfare is another important reason for accurate and closely spaced soundings of the ocean itself. Geological and geophysical explorations that are carried out in conjunction with detailed hydrographic surveys of Canada's enormous continental shelf will result in a series of charts that can be used for the exploitation of the shelf's resources as well as for navigation. All this is transforming the range of hydrographic surveys.

The Canadian Hydrographic Service has its headquarters in Ottawa, the centre of administrative direction, program planning, development and charting services. Field operations are carried out by three regional groups, each having its own base of operations. The Atlantic Region is based at the Atlantic Oceanographic Laboratory located in the Bedford Institute at Dartmouth, Nova Scotia, across the harbour from Halifax. This building, which contains offices, laboratories, and machine

ships and men

shops, also houses other government agencies concerned with the exploration of the ocean. It has a dock with space for several of the Department's ships, and facilities for overhauling launches and instruments. The A.O.L. is the home port for all hydrographic ships operating on the east coast, with the exception of the grand old lady of the fleet, the 55-year-old coal-burning *Acadia*, which traditionally docks at Pictou, N.S.

From Dartmouth, hydrographic ships fan out each spring on their survey cruises. These may cover the Gulf of St. Lawrence, the coasts and offshore waters of the Atlantic provinces, Labrador, Hudson Bay, or the eastern Arctic. The *Baffin* was designed especially to withstand the rugged Arctic service, and has done a great deal of surveying in frigid northern waters. In the Arctic, hydrographers assigned to the Polar Continental Shelf Project have had to adopt unusual methods of surveying in order to cope with the environment, such as through-the-ice sounding or sounding by helicopter. In the latter type of work, a low-flying helicopter tows an echo sounder just under the surface of the water.

The Central Region, with its headquarters at Ottawa, encompasses the continent's busiest marine traffic area — the Great Lakes and the St. Lawrence Seaway — and the other large lakes of Ontario and Manitoba, along with the waterways uniting them. Surveys here are carried on from launches, and hydrographic parties usually have their temporary

The *Parizeau*, one of the latest and most modern ships in the Hydrographic fleet. The *Parizeau* is based at Victoria and operates in British Columbia waters.

living quarters on shore. Many of the areas surveyed in this busy region are frequented by recreational boaters. With their ever-increasing numbers and the expansion of leisure time, the demand for small-craft surveys has increased far beyond the C.H.S.'s present capacities.
The Pacific Region has its headquarters at Victoria, B.C. Its surveys cover British Columbia's inland lakes, coastal and offshore areas, the Athabasca-Mackenzie waterway, and the western Arctic.

An enlargement of the Pacific Region headquarters is being planned, along lines similar to the Atlantic Oceanographic Laboratory.

Each ship and launch carries its complement of professional hydrographers and seamen. Ship's officers and men are usually hired at the home port, through the Canada Manpower Centres. Most of the seamen on east-coast ships come from Nova Scotia and Newfoundland ; frequently a good number of them are from the same town or village. Qualifications for ship's officers and crew on hydrographic ships are the same as for other sea-going vessels. The special navigational practices associated with hydrographic surveying are soon learned on board.

Hydrographers are in a category by themselves. The Canadian Hydrographic Service is the largest agency in Canada carrying out extensive marine surveys, and it has, of necessity, provided its own training for its staff. Future hydrographers must, however, possess a good grounding in mathematics and general survey techniques, and

ships and men

"Bombing" shoals by helicopter. Shallow water can often be seen better from the air than from launches. Spotters in helicopter drop small buoys to identify shoal for launch crews.

therefore most of the trainees entering C.H.S. come from technological institutes for land surveyors, of which Canada has five at present, or are university graduates in civil engineering. The higher the degree of formal education on entering C.H.S. the better the opportunities for advancement.

Trainees entering C.H.S. are usually around twenty years of age. They receive several months' instruction at the Ottawa head office, after which the *Baffin* is usually used to take them on a winter training cruise to the Caribbean. The choice of time and place is dictated by the need to use the ship during the Canadian off season, in waters not afflicted by the stormy winter weather. Trainees are full-fledged public servants and receive full salary. After their training cruise they are assigned to regular hydrographic surveys, under the direction of a senior hydrographer. The service now has some thirty senior hydrographers, each capable of taking charge of the operations of a survey ship. Cooperation between the hydrographer-in-charge and the captain is necessarily close. While the hydrographer is responsible for planning the day's operations, the captain is in charge of the ship's crew, and has a heavy responsibility for the safety of the ship which is usually working in unsurveyed waters.

One of the hydrographer's greatest challenges lies in the unavoidable long absences from home that some hydrographic surveying entails. Hydrographic survey parties may work far from home for months at a time. On the other hand, hydrographic surveying does not suffer from the monotony of much of commercial shipping in Canada, where a ship and its crew may shuttle back and forth between the same St. Lawrence Seaway ports for years. Hydrographers are conscious of being members of a highly specialized world-wide fraternity. Regardless of nationality, they are constantly aware that they are trying to serve the needs of all mariners. There is close liaison and cooperation between nations, which is fostered by the International Hydrographic Bureau, with its headquarters in Monaco. Hydrographers also take part, from time to time, in international conferences.

New high-speed sounding launch at work in Georgian Bay. Note the two hydrographers taking sextant fix.

Helicopter prepares to land on deck of *Baffin*.

During their surveys, hydrographers compile their data on field sheets, whose scale and coordinates have previously been worked out in the office, according to the scope of the survey. The extent of the area to be surveyed may vary greatly. The largest-scale surveys are generally those of harbours. Harbour charts must carry much more detail than general navigational charts, since harbours are places where large and relatively unwieldly ocean-going ships can get into trouble more easily than almost anywhere else. Also, there are many man-made alterations and structures that must be recorded. At the opposite end are charts covering large offshore stretches of water in which there are few or no islands, shoals, or other obstacles to navigation, and it is here that much smaller-scale surveys can be used.

At present, and for the foreseeable future, most survey requirements arise from the need for more detailed and larger-scale charts. Charts now exist for all of Canada's coast, but many are at small scales, often the soundings date back many decades, are too widely spaced, poorly positioned, and are therefore inadequate. Many of the older charts were compiled on the principle that five fathoms was the minimum safe depth along ocean coasts and three fathoms was the safe depth on the Great Lakes. Modern supertankers, however, draw over 80 feet, or nearly fifteen fathoms, and large "lakers" draw 25½ feet, so that many shipping lanes have to be sounded afresh. As new mines, industrial plants and refineries are being established, new water

planning and production

transportation routes and new harbours must be charted. This usually necessitates new marine surveys. Another new and rapidly growing type of survey pertains to small-boat routes in lakes and rivers. In former times, hydrographic surveys were meant to serve only the needs of commercial and naval traffic. Today, with thousands of pleasure craft crowding Canada's recreational waters, detailed surveys are needed of a multitude of lakes, rivers, bays, inlets and harbours frequented by tourists.

Once a survey has been completed and the soundings and other data entered on a plastic field sheet, the sheet is passed to compilation units at the head office in Ottawa and in the Victoria regional office. In Ottawa a complete chart-production establishment continues the cartographic process on all charts up to the printing stage. Printing itself is done in the Map Compilation and Reproduction Division of the Surveys and Mapping Branch — another unit of the Department of Energy, Mines and Resources.

In the chart-production process, huge photographic cameras change the scale of field sheets and other sources to the scale of the chart to be produced. After superimposing all these sources on clear plastic and contact-printing the whole onto a plastic sheet, the chart makers can then use a unique modern technical innovation that has enormously speeded up chart production. This is negative engraving, or "scribing",

Chief of a hydrographic field party enters the day's survey work on field sheet.

First step in the production of a new chart—the assembly of a transparent mosaic of the survey data.

Draftsman engraving a plastic negative of a new chart.

and it consists in using delicately shaped steel engraving instruments to scrape away the coating on the plastic sheet, thus producing a transparent design — in effect, a photographic negative. This negative is then used for making plates for offset printing.

However, even the publication of a new chart is only the start of a maintenance cycle. While about 50 new charts are published each year, almost 200 charts on the shelf require reprinting because of extensive changes in their navigational content or because of stock depletion. A steady stream of information arrives each week from other federal and provincial agencies and commercial sources which affects what is shown on the charts. Field units in each of the three regions make annual systematic revisory surveys of charted areas, verifying and correcting the information on the charts. Because of the large number of charts published and the size of the regions, it may take up to eight years to complete a revisory survey cycle, and then it is time to begin again. Industrial developments, silting of harbour approaches and channels and other man-made and natural processes never cease.

But even while the chart is on the stockroom shelf, it is being periodically up-dated from *Notices to Mariners*, which are issued weekly as a joint undertaking of the Department of Transport and the Canadian Hydrographic Service. These *Notices* show the latest changes in the positions and characteristics of buoys, lights, range lights, radio beacons and similar aids to navigation, or newly discovered shoals and other dangers. Most charts, before they are sent to a buyer, are hand-corrected to the very latest state of knowledge. Furthermore, after purchasing them, mariners are urged to update their charts from *Notices to Mariners*. All of the Canadian Hydrographic Service staff are well aware that mistakes on charts could lead to shipping casualties with loss of life and property, and they carry out their responsibilities accordingly.

The Canadian Hydrographic Service distributes about a third of a million charts each year, of which about 60 per cent are sold through

planning and production

authorized chart dealers, of whom there are about 260 in North America and 10 overseas.

While charts are the indispensable foundation of navigation, it is sailing directions, or "pilots", that make them really come to life. These pilots are books describing, in considerable detail, the best course to take when approaching harbours or negotiating passages. Beside describing the coast, they contain a wealth of information on shoals, anchorages, sea ice, magnetic anomalies, climate, winds, currents, and facilities available in the various ports, — in short, information that is of interest to the mariner. Pilots are compiled from many different sources and are kept up to date by the issue of annual supplements and periodic new editions. Separate pilots for the following areas are now in print: Newfoundland, Nova Scotia and Bay of Fundy, Saint John River, Gulf of St. Lawrence, St. Lawrence River, Great Lakes (two volumes), British Columbia (two volumes), Great Slave Lake and Mackenzie River, Labrador and Hudson Bay, Arctic Canada (three volumes). Possibly the most interesting of these is Arctic Canada, Vol. I, which contains a concise account of exploration and geography of the Canadian Arctic, and the factors affecting navigation in these waters that are becoming increasingly important to the Canadian economy.

Tide and current tables are compiled for all ports of Canada. They are issued annually and enable harbour masters, seafarers, fishermen, and other interested persons to foretell the time and range of high and low water. The factors on which such tidal predictions are based are enormously complicated, and include tide-gauge measurements, positions of sun and moon, the effect of the earth's rotation, friction, and, finally, the highly irregular shape and depth of the oceans. The world's largest tide, up to a whopping 53 feet between high and low water, occurs in the Bay of Fundy. In that area, ships tied up at docks may rest on dry bottom at low tide. Currents are also difficult to measure and to predict, but their prediction is essential, especially in the narrow passes that abound on the British Columbia coast.

planning and production

Canadian Survey Ship *Baffin* in Arctic ice.

Hydrographer trainees working on an island in the West Indies draw curious spectators.

Tidal measurements are made by tide gauges, which may be either permanent or temporary. Tide gauges are located at all important harbours and other coastal points about 150 miles apart, and provide important long-term information about changes in mean sea level. They consist of a clock-driven graph and a float which moves up and down with the rise and fall of the tide. Some tide gauges are activated by changes in water pressure ; they are used at temporary gauging stations and in the Arctic where ice would interfere with float mechanisms.

Water-level gauges also are installed throughout the Great Lakes-St. Lawrence system. Their information is vital to commercial shipping, hydroelectric power and shore-line properties. Six of these gauges, in key locations, automatically give water-level information when consulted by telephone.

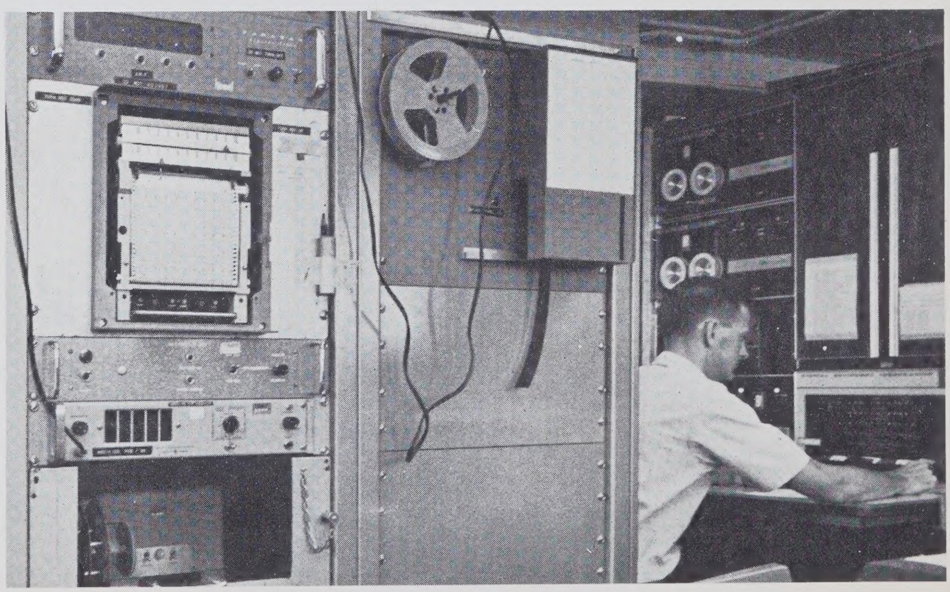
Mariners realized early that even the most precise soundings would not ensure safe passage in waters containing strong and variable currents. Information on the speed and direction of currents is therefore placed on charts. However, few currents are obliging enough to run always in the same direction and at the same speed. Along the Canadian coast — and especially in the much-frequented Gulf of St. Lawrence and around Vancouver Island — currents frequently change both speed and direction. In addition, several currents may be super-

planning and production

imposed at different depths. All this makes current surveys a highly specialized task.

The standard instrument for measuring currents is the current meter. Essentially, it consists of a bomb- or cigar-shaped hull containing a compass, a speedometer, and an automatic camera which takes pictures of the compass and speedometer at fixed intervals. The speedometer is turned by a water-driven propeller. Current meters are anchored to the bottom by heavy weights, which keep them at a predetermined depth below the surface of the water. They are usually left in place for 29 days to record a complete tidal cycle.

The science of hydrography, like any other science, is constantly progressing, and the Canadian Hydrographic Service does not sit back and wait for improvements in instruments and methods to reach it from the outside. Faced with ever-increasing demands on its limited resources, the Service is constantly harnessing modern technological advances. At Ottawa, as well as at regional headquarters, there are research and development units, whose main effort is concentrated on the automation of surveying and cartography, which, in turn, is expected to lead to greater efficiency and speed of operation. Hydrography presents an exciting challenge to meet the demands of deep-sea charting and the exploration of the bottom of the oceans — the last great frontier remaining on earth.



Magnetometer, gravimeter and computer installation aboard CSS *Baffin*.

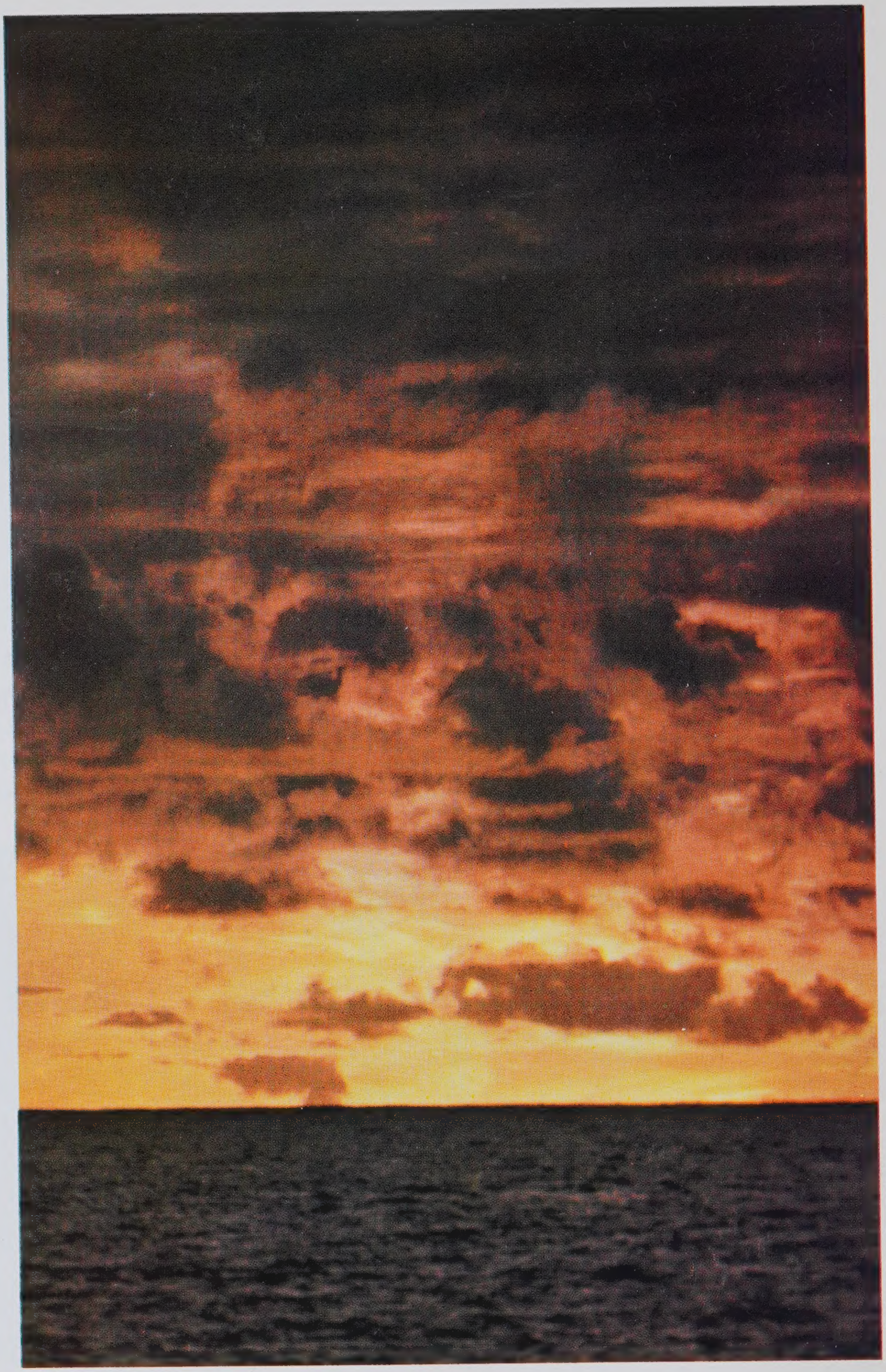
Canada has the world's longest coastline — 117,000 statute miles.

Canada's continental shelf covers 1,452,000 square miles, 42% of its land area.

185 million tons of cargo moved through Canada's waters in 1967.
- — 55 million tons in coastal shipping between Canadian ports.
- — 50 million tons in imports.
- — 85 million tons in exports

780,000 pleasure crafts are registered in Canada.

The Canadian Hydrographic Service maintains over 1,000 navigation charts of Canada's navigable waters.



On the extreme right, a portion of Canadian Hydrographic Service Chart 4216, Pubnico to Yarmouth. Adjacent to it is part of a field sheet used in its compilation.

For further information about the activities of the Canadian Hydrographic Service and careers in Hydrography and Cartography, write to:

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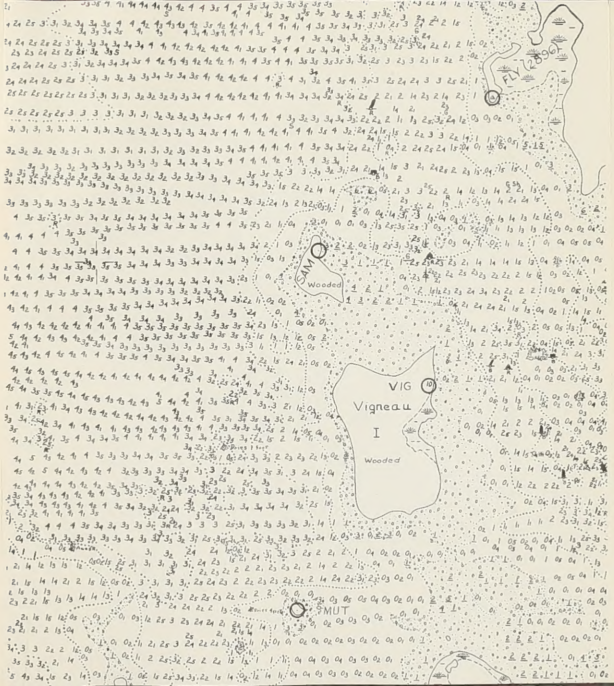

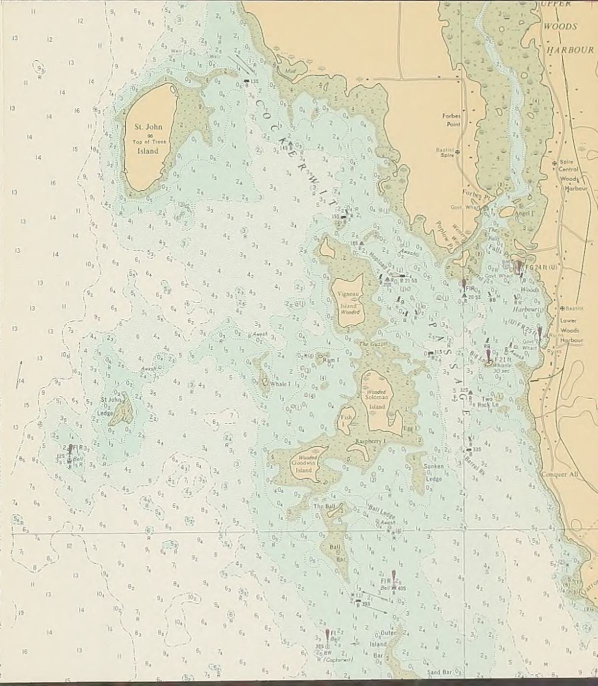

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